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Extremely long hard bursts observed by Konus-Wind

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Abstract. We report the observations of the prompt emission of the extremely long hard burst, GRB 060814B, discovered by Konus-Wind and localized by the IPN. The observations reveal a smooth, hard, ∼40-min long pulse followed by weaker emission seen several hours after the burst onset. We also present the Konus-Wind data on similar burst, GRB 971208, localized by BATSE/IPN. And finally we discuss the different possible origins of these unusual events.

Keywords: gamma-ray bursts
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INTRODUCTION

Konus-Wind is a gamma-ray all-sky spectrometer [1] which has been successfully operating since November 1994. Wind orbit is far from the Earth magnetosphere (at distance of ∼1–7 light seconds) that enables nearly uninterrupted observations of all sky under very stable background. In the waiting mode Konus-Wind measures the count rates in three energy bands which covers the ∼15–1000 keV range with accumulation time of 2.944 s. This mode enables observations of ultra long gamma-ray bursts with duration ≥500 s. During 13 years of observations Konus-Wind has detected two extremely long, single pulsed, hard GRBs.

GRB 060814B

A very long burst was detected by Konus-Wind in the waiting mode at 2006-08-14 T_0=37070 s UT (10:17:50). The burst light curve shows a single, smooth, FRED-like

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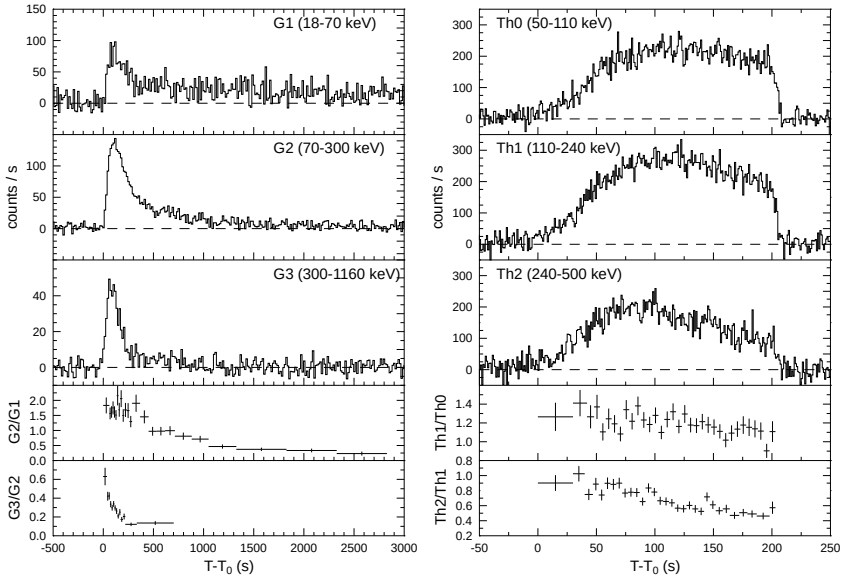

FIGURE 1. Konus-Wind (*Left*) and Suzaku-WAM (*Right*) background subtracted light curves of GRB 060814B in three energy bands and the hardness ratios, T_0=37070 s UT (10:17:50).

pulse with a duration of $\simeq$2700 s. The most intense part of the burst (initial several hundreds seconds) was also detected by Ulysses, Mars Odyssey (HEND), Suzaku-WAM, and INTEGRAL-SPI-ACS. That enabled to localize the burst to the $\simeq$7.1 deg^2 3σ IPN error box, whose coordinates are given in Table 1. The Suzaku-WAM light curve shows a sharp decline at T-T_0 $\simeq$200 s due to source set below the horizon (see Fig. 1). This occultation step let us to derive much smaller combined IPN/WAM box with the area of $\simeq$0.6 deg^2 (given in Table 1). The galactic coordinates of the box center are l, b = 162.88, +6.06 deg.

The Konus-Wind light curve of GRB 060814B in three energy bands is shown in Fig. 1. The burst demonstrates strong hard-to-soft spectral evolution with the hardest spectrum at the burst onset. After the end of the main pulse there is an extended emission seen in the G1 and G2 bands during several hours (4 hours in the G2 at $> 4\sigma$-level and even longer in the G1). The emission was detected by the same detector which observed the main pulse, so it might be a burst tail. Unfortunately the localization area occurred in the BAT FoV only in $\simeq$11 hours after the burst onset. Nothing evident was found in the BAT data of the 500-s long observation (obsID 00035631001).

The Suzaku-WAM multichannel spectrum accumulated from T_0 to T_0+200 s is well fitted (in the 80–2000 keV range) by CPL model: $dN/dE \propto E^{-\alpha}\exp[-(2-\alpha)E/E_p]$ with $\alpha = 0.19 \pm 0.14$, $E_p = 477(-27,+31)$ keV (χ^2=21/23 dof). The errors are given at 90% confidence level. The Konus-Wind 3-channel spectrum for the same interval yields $\alpha = 0.89 \pm 0.07$, $E_p = 544 \pm 52$ keV. The errors are estimated at 1σ level by propagation of errors in the observed counts (here and below). Using the KW 3-channel data we also estimated the spectral parameters for whole burst, for the hard pulse, and for the possible tail. The results are given in Table 2. The estimated burst fluence is $(2.35 \pm 0.22) \times 10^{-4}$ erg cm^{-2} (18–1170 keV). The fluence of the tail is

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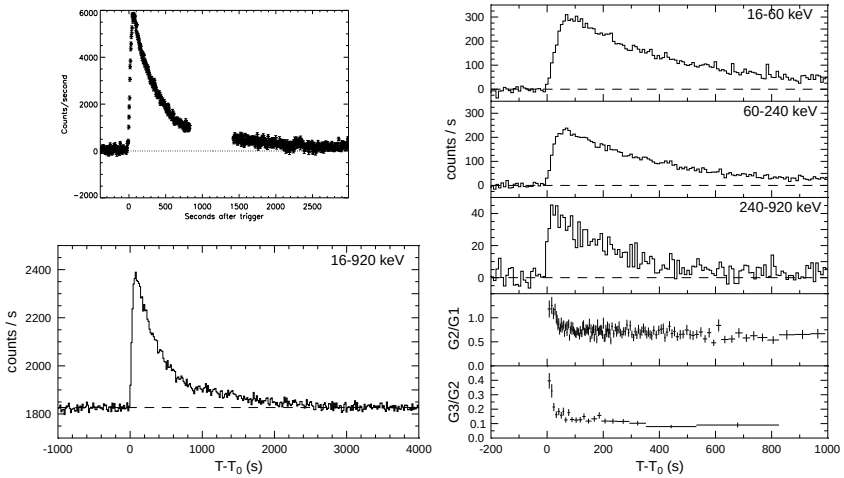

FIGURE 2. **Left**: Konus-Wind (*Bottom*) and BATSE light curves (*Top*: background subtracted, 20–1000 keV range) of GRB 971208. **Right**: Konus-Wind background subtracted light curve in three energy bands and the hardness ratios. T_0=28092 s UT (07:48:12).

$(2.1 \pm 0.2) \times 10^{-4}$ erg cm^{-2} in the same range.

GRB 971208

An unusually long, smooth, single pulsed gamma-ray burst was detected by BATSE at 1997-12-08 28092.1295 s UT (trigger 6526: [2]). This burst was observed by Konus-Wind in full entirety (see Fig. 2). The total burst duration is $\simeq$2500 s. One can see in Fig. 2 the BATSE light curve which shows a similar duration. There is no any sign of extended emission after T-T_0 $\simeq$2500 s.

The burst demonstrates a similar to GRB 060814B hard-to-soft spectral evolution. Using the KW 3-channel data we estimated the spectral parameters for the hard pulse, and for the whole burst (see Table 2). The estimated burst fluence is $(2.55 \pm 0.11) \times 10^{-4}$ erg cm^{-2} (15–1000 keV). The fluence reported by BATSE for the first 800 s is $(1.86 \pm 0.03) \times 10^{-4}$ erg cm^{-2} in the 25-1800 keV range [2].

DISCUSSION

Two obvious factors can make longer the burst: cosmological time dilation and relativistic curvature effect. Assuming, for example, $z = 10$ we would have $E_{iso} \simeq 2 \times 10^{55}$ erg, $\Delta T_{rest} \simeq 230$ s, and $E_{p,rest} \simeq$3700, and 1600 keV correspondingly for GRB 060814B and 971207. Such E_{iso} is about a factor of 10 greater than the largest known value. But we should take in account a high probability of lensing for such redshift. $E_{p,rest} \simeq$3700 keV seems to be a bit large, but it is not exceptional: Swift GRB 050717 had $E_p \simeq$ 1900 keV [3], so even assuming $z \simeq 1$, it would correspond to $E_{p,rest} \simeq$3800 keV. Hence, these bursts might be high redshift GRBs magnified by lensing. The pulse shapes and the character of spectral evolution indicate that the curvature effect (e.g. [4],[5]) may

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TABLE 1. Localization of GRB 060814B

	IPN box (J2000)		**Combined IPN/WAM box (J2000)**	
	RA, deg	**Dec, deg**	**RA, deg**	**Dec, deg**
Center	81.98	+47.85	81.19	+46.60
Corner1	83.20	+46.76	80.73	+48.66
Corner2	80.86	+44.66	80.76	+47.55
Corner3	80.72	+48.94	81.42	+45.19
Corner4	83.30	+51.11	81.66	+45.40

TABLE 2. Spectral parameters of GRB 060814B and GRB 971208

GRB 060814B			**GRB 971208**		
Time interval s	α	E_p **keV**	**Time interval s**	α	E_p **keV**
0–700	0.91±0.07	374±30	0–485	1.246±0.033	165±7
0–2700	1.46±0.07	341±61	0–2500	1.185±0.075	144±12
2700–12300*	2.7±0.2	–			

* spectrum was fitted by a simple PL

play a main role in forming the pulses. For pulses created purely by the curvature effect $\Delta T \propto (1+z)R_s/\Gamma^2$. Hence, very long duration may be due to unusually large shell radius R_s. That requires some specific conditions in the circumburst medium and/or in the shock.

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